NASA's Cloud Absorption Radiometer:
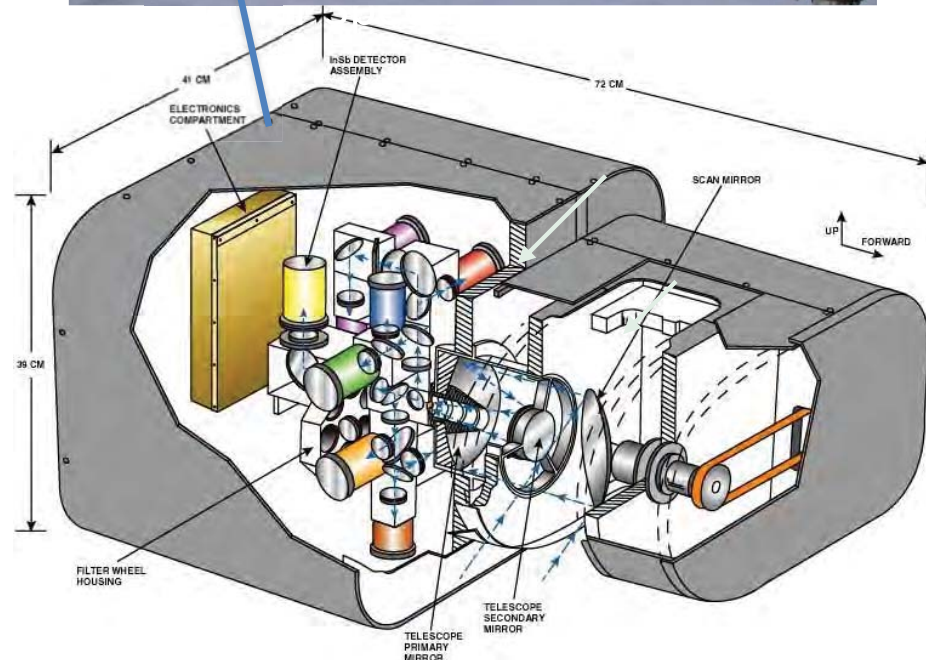
Miguel O. Román
GSFC Terrestrial Information Systems Laboratory

Overview of the CAR Instrument
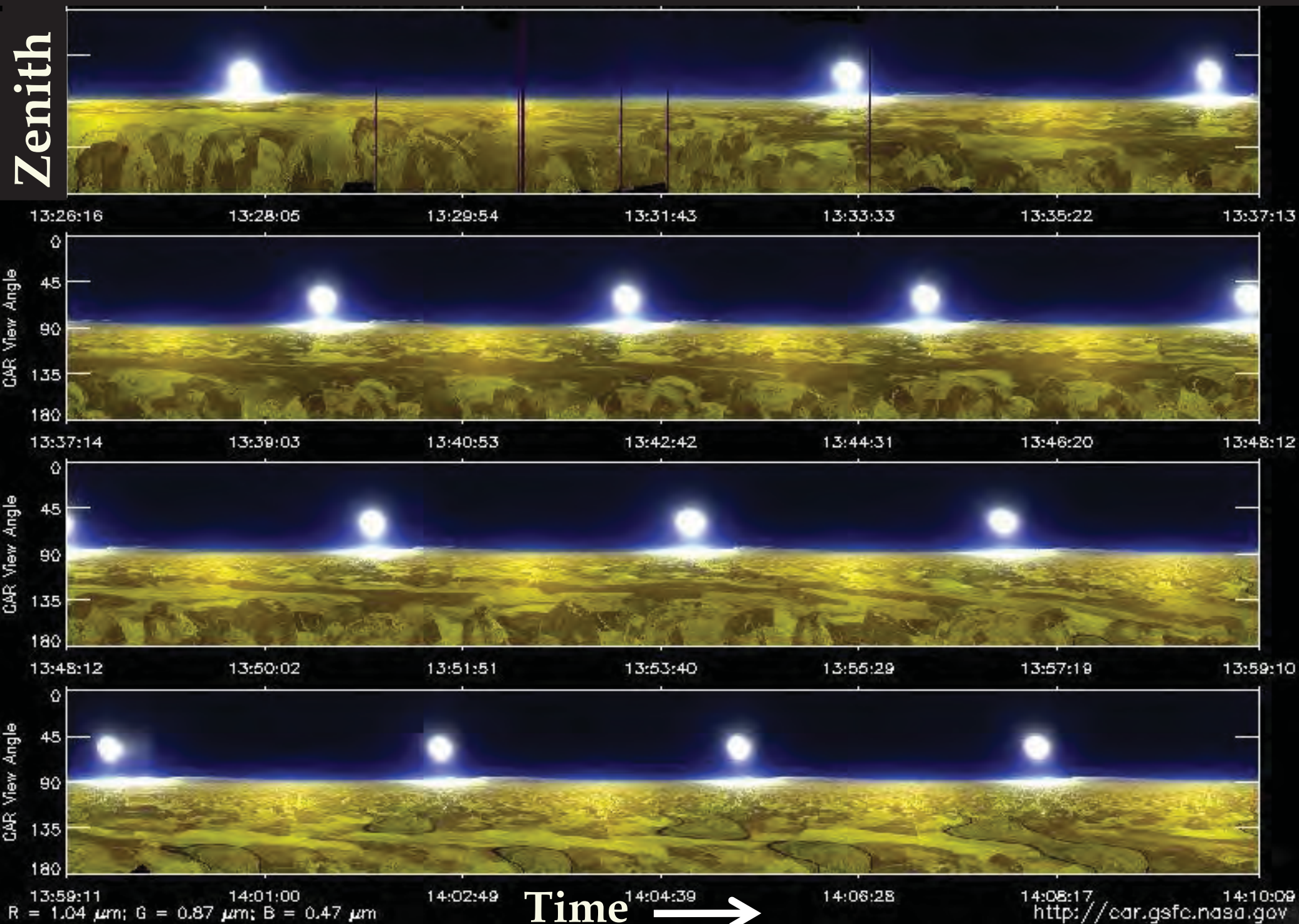
Sensor Characteristics:
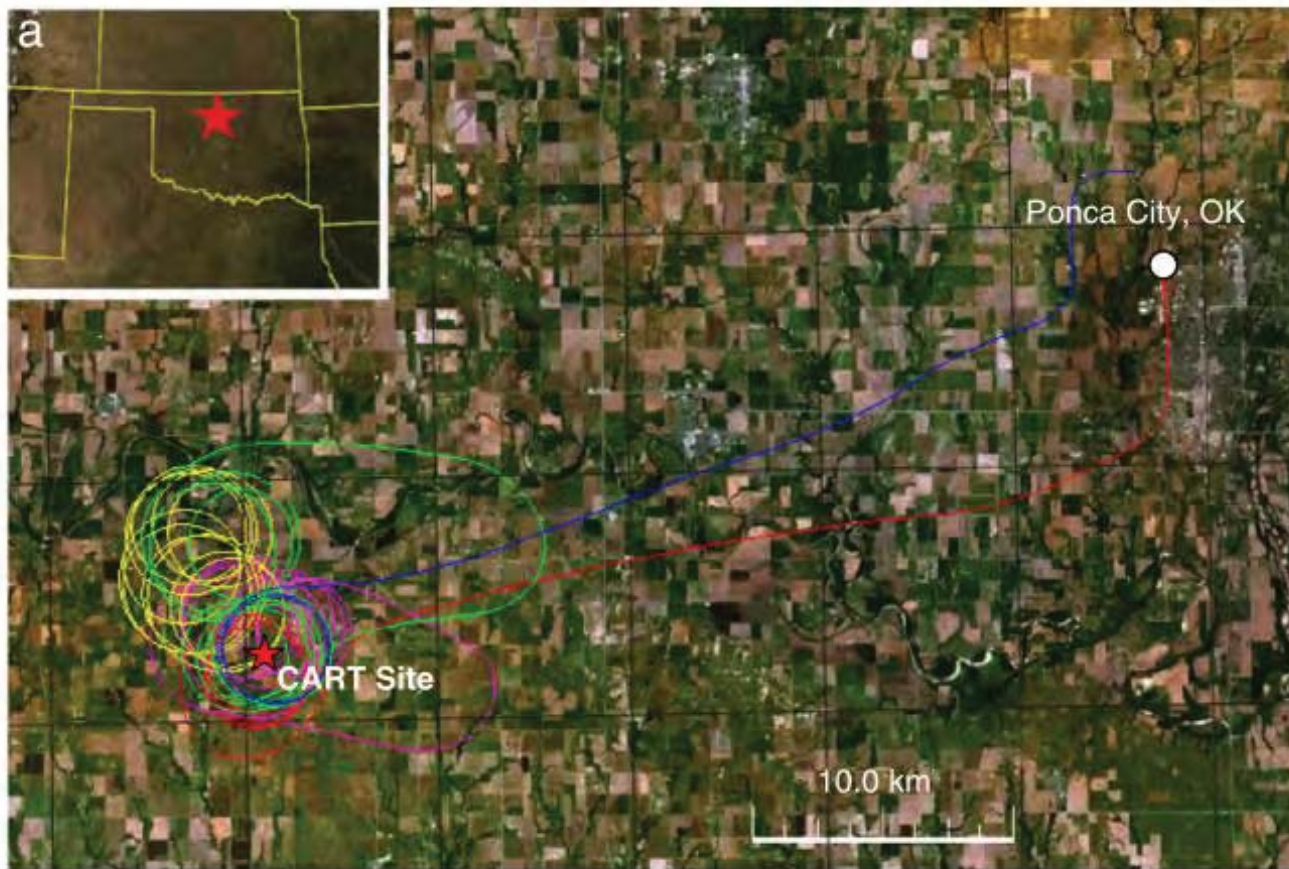
➢ 14 spectral bands (0.34 to 2.29 μm)

➢ scan $\pm 95°$ from horizon on right-hand side of aircraft or image 190° horizon-to-horizon

➢ field of view 17.5 mrad (1°)

➢ scan rate 1.67 Hz (100 rpm)

➢ data system 9 channels @ 16 bit

➢ 395 pixels in scan line

➢ Platform: NASA P-3B

CAR

NASA P-3B

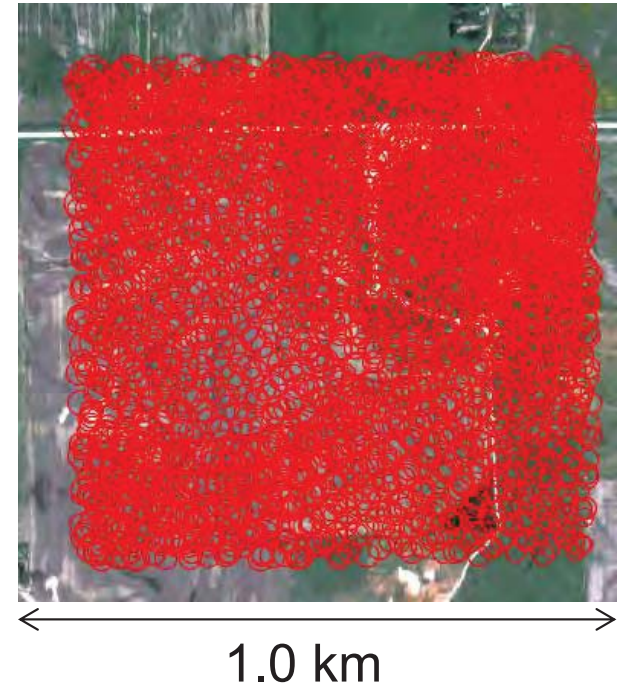CAR Quick-Look Image: CLASIC Flight #1928

CLASIC'07

IKONOS 2.4 m RGB
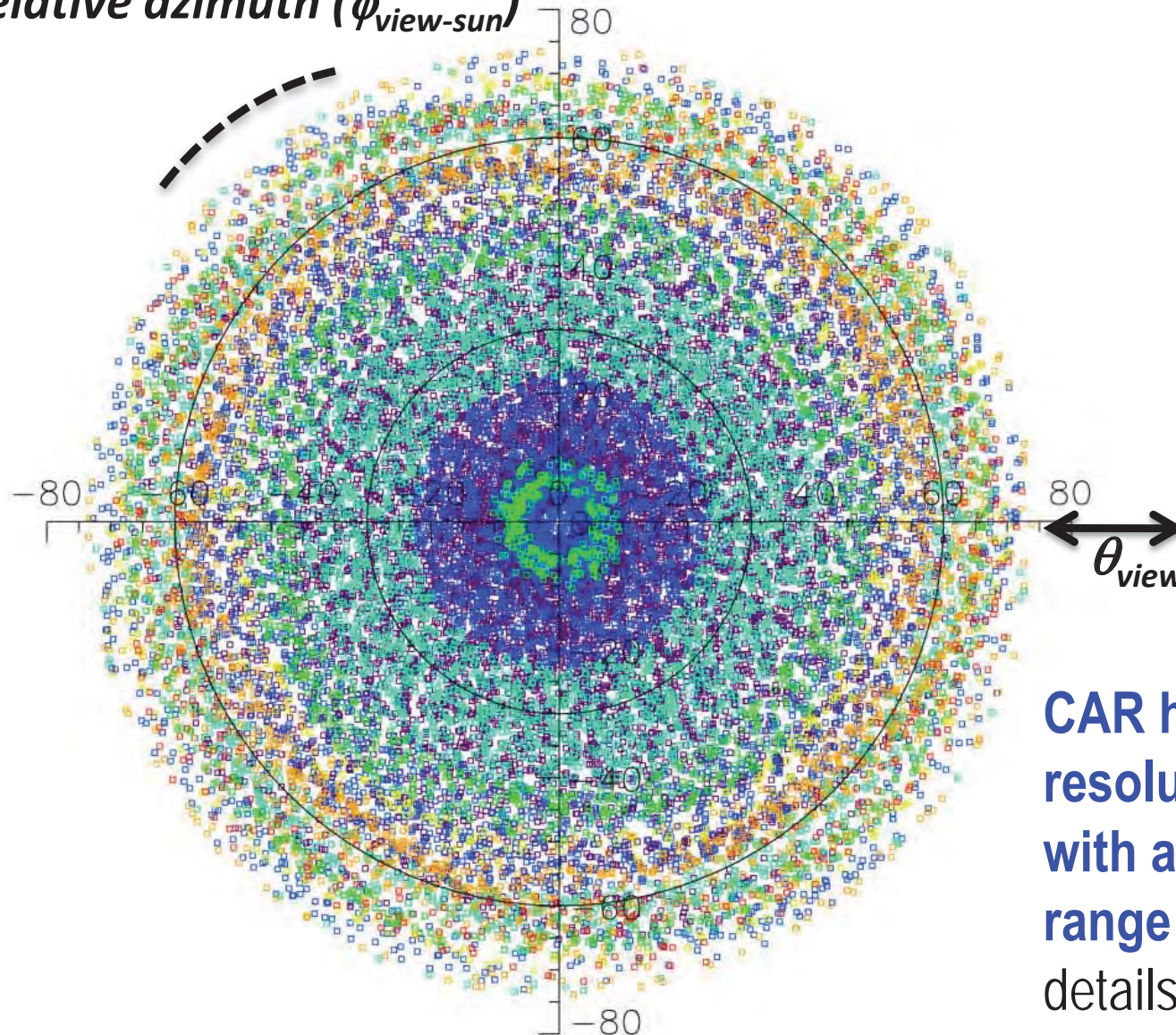

1.0 km

Coincident
Surface BRF and Albedo from Ground, Aircraft, and Satellite.

Best ever
Multi-scale observations of the Surface BRDF.

Cloud Absorption Radiometer: BRDF Sampling

Relative azimuth ($\phi_{view-sun}$)

θ_{view}

Pixel Size (GIFOV)

- ▢ 5−20m
- ▢ 20−40m
- ▢ 40−60m
- ▢ 60−80m
- ▢ 80−100m
- ▢ 100−250m
- ▢ 250−500m

CAR high angular and spatial resolution (1° IFOV) coupled with a high SNR and dynamic range provides unmatched details of the radiance field above clouds and various surfaces.

Román et al. 2011 - RSE

CAR Science Focus Areas

Focus Area	**Current** and **Potential** Applications	Campaign/ Project	Key Players[†]
Cryospheric Science	• Retrieval of BRDF/albedo/snow grain size; • Satellite aerosol retrieval over snow; • Surface energy balance of seasonal snow cover for snowmelt estimation. • Characterize the effects of blowing snow & cloud forward scattering on altimetry (Lidar) measurements to evaluate the imprint of climatic changes on ice dynamics (e.g., flow of ice & mass balance).	ARCTAS, IceBridge[§], ICESat	Lyapustin et al. (2010) Gatebe et al. (2010) Arnold et al. (2002) **Collaborators:** Marshak, Yang, Hall, Kahn, Schaaf
Terrestrial Ecology & Biospheric Science	• MODIS/MISR Land and Aerosol Product Cal/Val efforts; • Diurnal-to-seasonal characteristics of surface energy balance; • Retrieval of surface biophysical parameters (e.g., BRDF-Albedo, VI, and Clumping index) at multiple spatial scales and angular distributions; • Retrieval of vegetation structural parameters (e.g., leaf size, canopy height, and canopy roughness) over complex heterogeneous surfaces.	ARCTAS, CLASIC, INTEX-B, Skukuza, CLAMS, SAFARI 2000, TARFOX, SCAR-B, CLAMS	Román et al. (2011;2013) Gatebe et al. (2003; 2010) Soulen et al. (2000), Tsay et al. (1998) **Collaborators:** Schaaf, Wang, Shuai, Masek, Butler, Georgiev, Cooper, King, Ni-Meister, Varnai, Marshak
Freshwater/ Coastal & Marine Climate Science	• Retrieval of surface BRDF/albedo over aquatic biomes (e.g., coastlines, estuaries, ponds, and lakes) under clear and turbid waters. • Impact of anthropogenic forcing (e.g., ship wakes) on ocean energy balance.	ARCTAS-CARB, CLAMS, ARCTAS	Gatebe et al. (2005;2010) **Collaborators:** Lyapustin, Stamnes, Wilcox, Wang
Cloud & Smoke Radiative Properties	• Cloud/Smoke interior: Energy budget; Actinix flux; • Wildfire smoke: Effects of boreal/savanna fire regimes on atmospheric chemistry, global carbon cycling, and climate; • Precipitating cloud: Impact on land-atmosphere interactions and locally generated cumulus convection. • Retrieval of Cloud Effective Radius.	SCAR-B, SAFARI 2000, Skukuza, CLASIC, ARCTAS	Gatebe et al. (2003;2011) King (1992) **Collaborators:** Ichoku, Kahn, Melnikova, Marshak, Ewald, Zinner, Varnai, Ewald

[†]Cited publications are available at: http://car.gsfc.nasa.gov/publications/
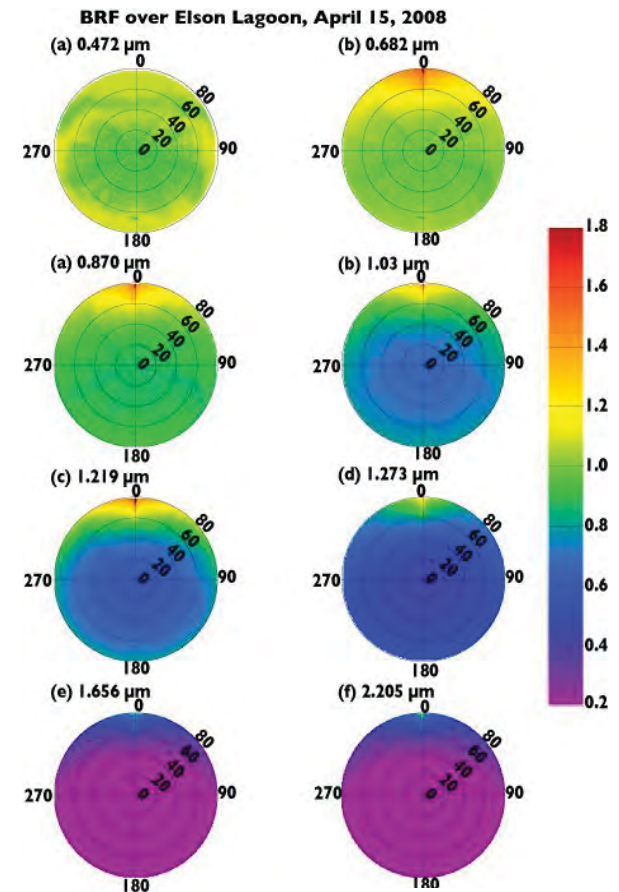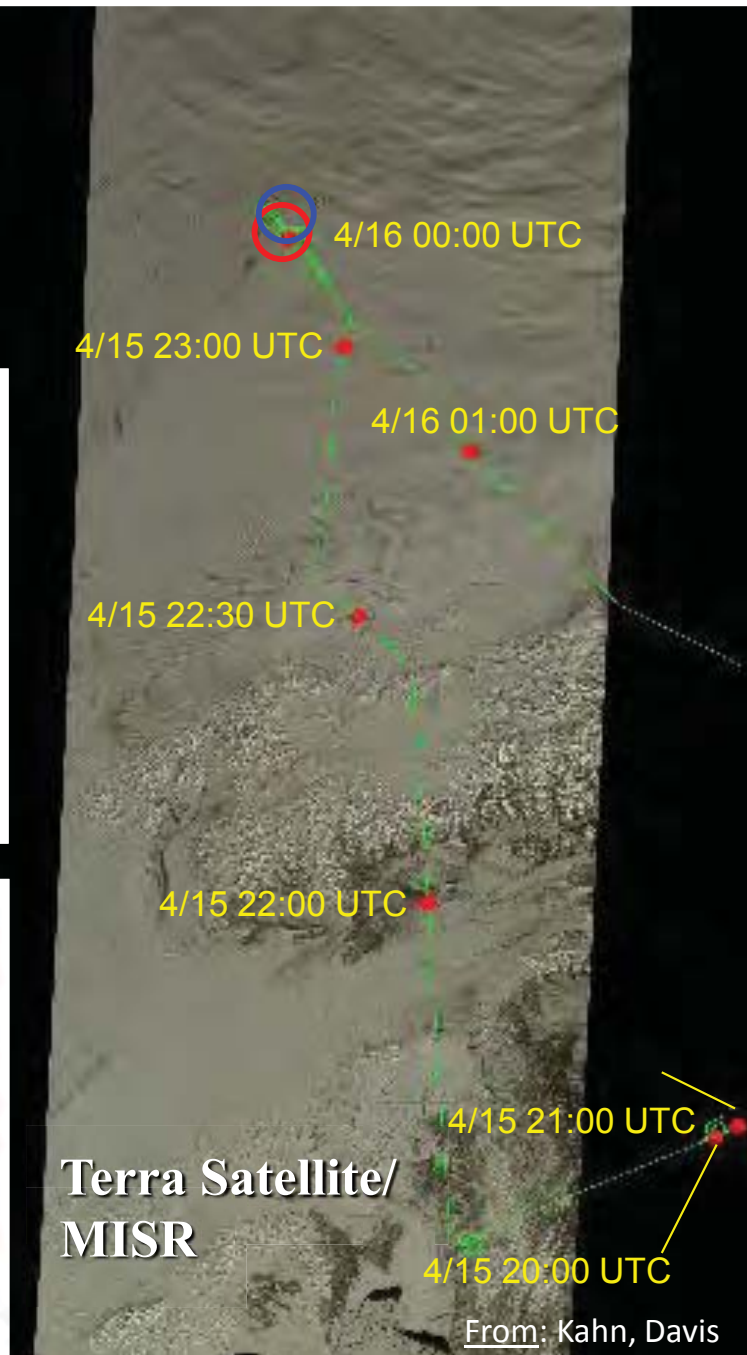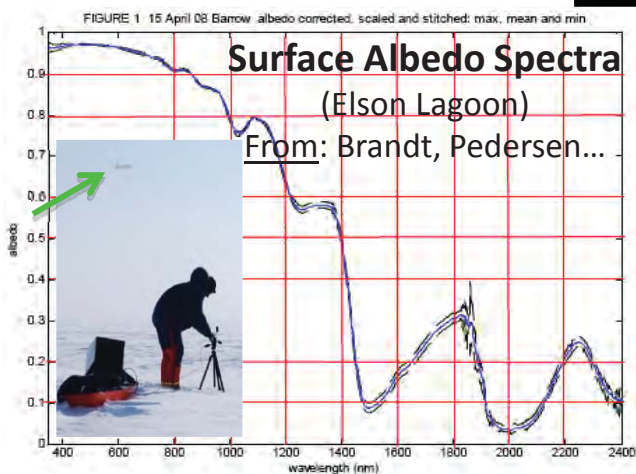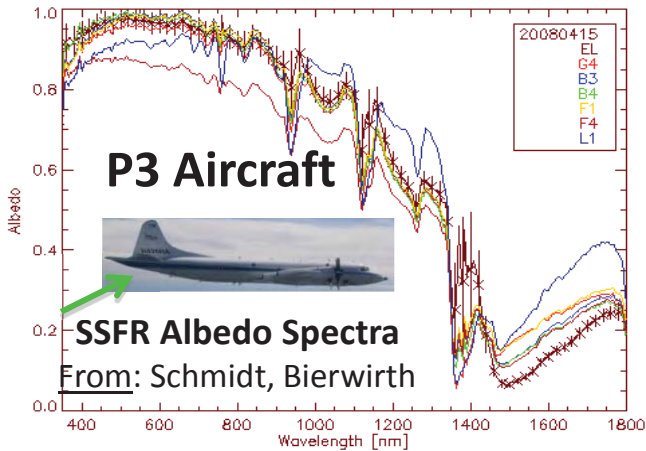
ARCTAS'08: Barrow/Elson Lagoon 15 April 2008
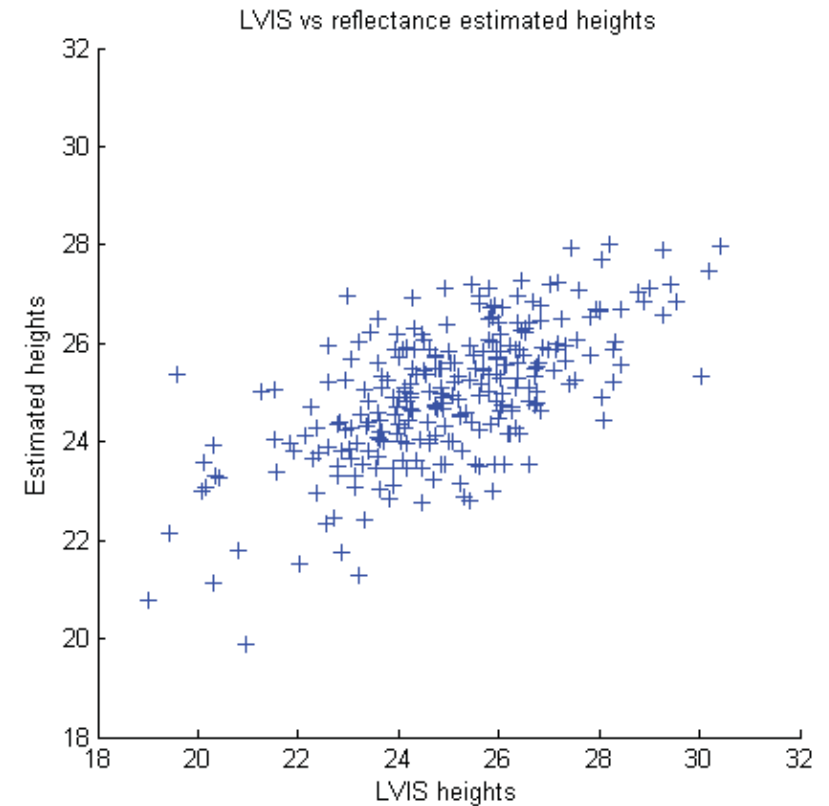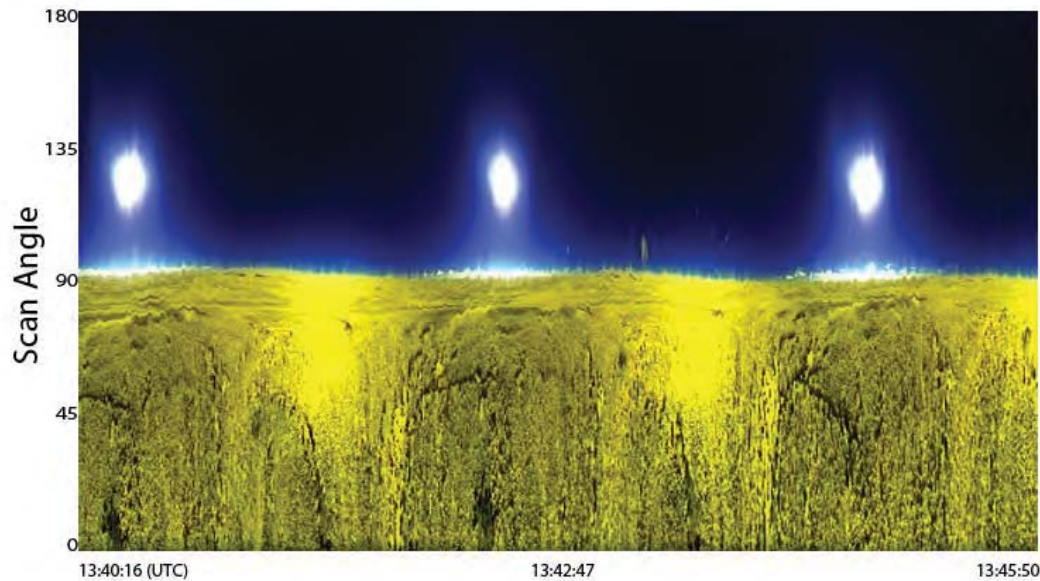## Lat 71.3° Lon -156.7; SZA 61.1° [Terra at 22:30 UTC]

Coincident
Snow Albedo & BRF from Surface, Aircraft, and Satellite.

Best ever multi-scale observations over snow-covered areas.

P3 Aircraft

SSFR Albedo Spectra
From: Schmidt, Bierwirth

Surface Albedo Spectra
(Elson Lagoon)
From: Brandt, Pedersen…

4/16 00:00 UTC
4/15 23:00 UTC
4/16 01:00 UTC
4/15 22:30 UTC
4/15 22:00 UTC
4/15 21:00 UTC
4/15 20:00 UTC

Terra Satellite/ MISR

From: Kahn, Davis

BRF over Elson Lagoon, April 15, 2008
(a) 0.472 μm
(b) 0.682 μm
(a) 0.870 μm
(b) 1.03 μm
(c) 1.219 μm
(d) 1.273 μm
(e) 1.656 μm
(f) 2.205 μm

CAR Spectral BRF
From: Gatebe

— P-3 Flight Path
◯ Barrow AERONET Site
◯ Ground Measurements

ECO/3D: Canopy height estimation (Harvard Forest LTER)

Correlation coefficient:

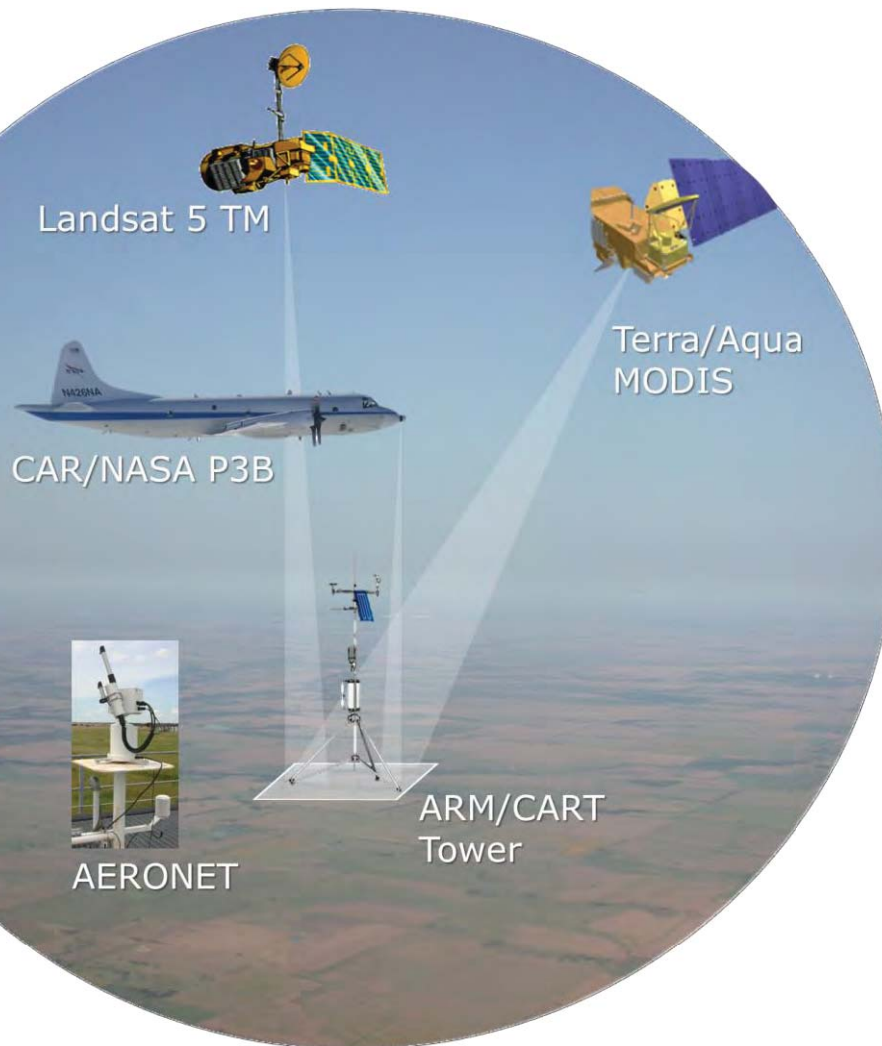Multi angles surface reflectance   0.65

Escape probability 0.76

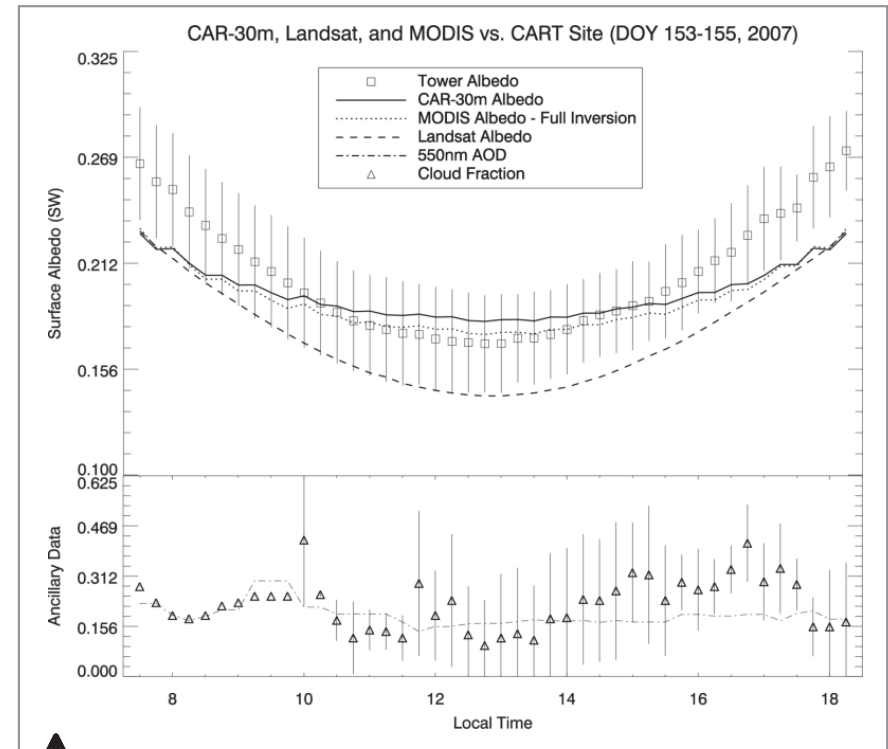Maple leaf reflectance and broadleaf pixels

Credit: Zhuosen Wang (UMB)

Use of in situ and airborne multiangle data to assess MODIS- and Landsat-based estimates of directional reflectance and albedo (Román et a., 2013 – TGRS)
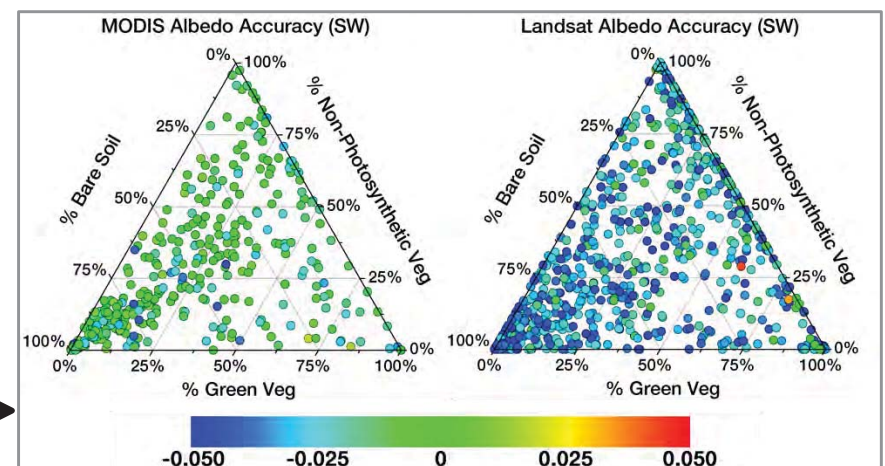

Measurement configuration for multiscale assessment of MODIS- and Landsat- albedos.

Pixel-specific accuracy of MODIS- and Landsat-derived albedos.

Tower albedos vs. CAR, MODIS, and Landsat.

Summary + Final Thoughts…

- Previous and ongoing efforts offer a unique set of tools and capabilities for ensuring mission readiness.

  - **CLASIC'07:** First comprehensive assessment BRDF/albedo at different spatial scales (30 – 500m).
  - **ARCTAS'08:** Best ever multi-scale observations over snow-covered areas.
  - **ECO/3D'11:** Capability for mapping canopy physiognomy/structure (e.g., BRDF shape & tree height) from multiangle BRF data.

- From a scientific perspective, ***SnowMASS is the next logical milestone for the CAR***.